Redox State of Cd in Wild and Transgenic Plants

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Recently wild and transgenic plants were examined by XANES for the presence of Cd^0 and Cd^{+2} at Beamlines X-18B and X-19A at the National Synchrotron Light Source. The transgenic plants were developed to use in phytoremediation of arsenic from contaminated soils. There is evidence that these plants may also reduce Cd^{+2} to Cd^0. Determining the redox state of Cd in transgenic plants is important because it indicates if the transgenic operon is functioning. Concentrations of Cd were only about 8 mg/kg, making this determination a challenge. We first tried to use the L_{III} X-ray edge (3.538 keV), on Beamline X-19A, which clearly differentiates between Cd^0 and Cd^{+2} but the concentrations were too low to allow a definitive identification of the redox state. We then moved to X-18B where the much higher energy K edge (26.711 keV) could be observed. Very low concentrations of Cd can be observed at this energy but the differences in the edge position are more subtle than at the L_{III} edge. XANES of Cd^0 and Cd^{+2} standards showed that post-edge structure is a good indicator of Cd redox state (Fig. 1). Samples of transgenic plants and wild type plants (both of which were grown on Cd contaminated medium) were analyzed by XANES and showed no difference in redox state; they were all Cd^{+2}. If the transgenic plants were operating on Cd there should have been a difference between the wild and transgenic plants. However, we are concerned that sample preparation (freeze drying) may not have preserved the Cd redox state. Subsequent analysis will be made on living plants. This technique is especially important to Applied PhytoGenetics because much of their transgenic plant work focuses on redox changes in metals within the plants. Results from these experiments are of interest because if Cd is being reduced, then the gene that was transferred is actually working on more than one metal, an important finding.

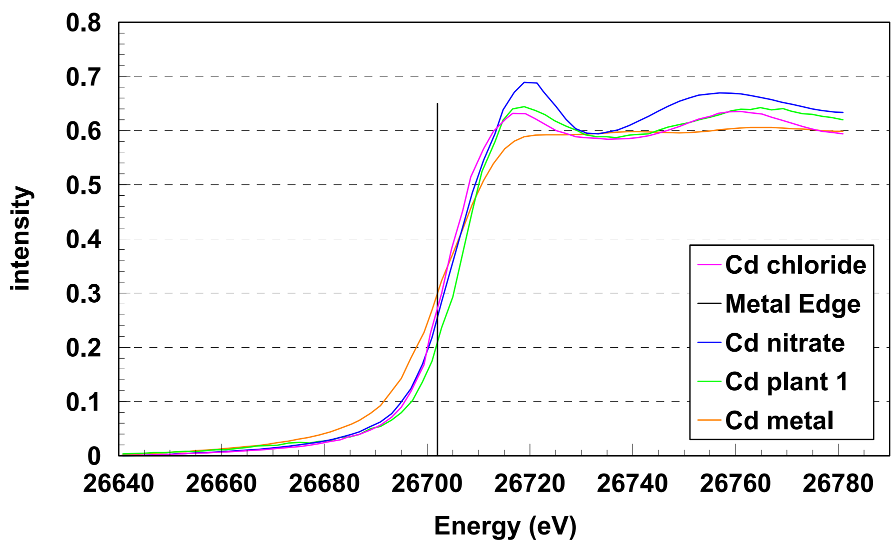

Figure 1. These XANES scans, indicating the redox state of cadmium in standards and plant samples, were done at Beamline X-18B at the NSLS. Seven plant scans (only one is shown for clarity) are clearly different than the Cd^0, indicating that the Cd in the plants was Cd^{+2} and was not changed in the plant.